

Law Offices
FOLEY & LARDNER
Suite 500
3000 K Street, N.W.
Washington, DC 20007-5109
(202) 672-5300

JCS74 U.S. PTO
09/435354
11/08/99

TO: Assistant Commissioner for Patents
Box Patent Applications
Washington D.C. 20231

Attorney Docket No.085874/0193

(must include alphanumeric codes if no inventors named)

UTILITY PATENT APPLICATION TRANSMITTAL
(new nonprovisional applications under 37 CFR 1.53(b))

Transmitted herewith for filing is the patent application of:

INVENTOR(S): Neil HARRIS and Graham BANK

TITLE: LOUDSPEAKERS

In connection with this application, the following are enclosed:

APPLICATION ELEMENTS:

XX Specification - 16 TOTAL PAGES

(preferred arrangement:)

- Descriptive Title of the Invention
- Cross Reference to Related Applications
- Statement Regarding Sponsored R&D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings (if filed)
- Detailed Description
- Claim(s)
- Abstract of the Disclosure

XX Drawings - Total Sheets 7

Declaration and Power of Attorney - Total Sheets

 Newly executed (original or copy)

 Copy from a prior application (37 CFR 1.63(d))

(relates to continuation/divisional boxes completed) - NOTE: Box below

 DELETION OF INVENTOR(S) - Signed statement attached deleting inventor(s)
named in the prior application, see 37 CFR 1.63(d) (2) and 1.33(b).

 Incorporation By Reference (useable if copy of prior application
Declaration being submitted)

The entire disclosure of the prior application, from which a COPY of the
oath or declaration is supplied as noted above, is considered as being
part of the disclosure of the accompanying application and is hereby
incorporated by reference therein.

 Microfiche Computer Program (Appendix)

 Nucleotide and/or Amino Acid Sequence Submission (if applicable,
all necessary)

 Computer Readable Copy

 Paper Copy (identical to computer copy)

 Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

 Assignment Papers (cover sheet & document(s))

 37 CFR 3.73(b) Statement (when there is an assignee)

 English Translation Document (if applicable)

 Information Disclosure Statement(IDS) with PTO-1449. Copies of IDS Citations

 Preliminary Amendment

XX Return Receipt Postcard (MPEP 503)

The PTO did not receive the following
linked item(s) NO check

66/80/11
1639 U.S. P
11/08/99

- ☐ Small Entity Statement(s)
☐ Statement file in prior application, status still proper and desired.
☐ Certified Copy of Priority Document(s) with Claim of Priority
(if foreign priority is claimed).
☐ OTHER:

If a **CONTINUING APPLICATION**, check appropriate box and supply the requisite information:

☒ This application is a Continuation-in-part (CIP) of application No. 08/707,012, filed September 3, 1996. This application also claims the benefit of provisional application Nos. 60/150,817, filed August 26, 1999, and provisional application No. 60/150,824, filed August 26, 1999.

☐ Amend the specification by inserting before the first line the following sentence: --This application is a ☐ continuation, ☐ divisional or ☐ continuation-in-part of application Serial No. ☐, filed ☐--

CORRESPONDENCE ADDRESS:

Foley & Lardner Address noted above.
Telephone: (202) 672-5300
Fax Number: (202) 672-5399

FEE CALCULATIONS: (Small entity fees indicated in parentheses.)

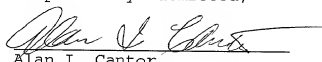
(1) For	(2) Number Filed	(3) Number Extra	(4) Rate	(5) Basic Fee \$760 (\$380)
Total Claims	28 - 20 =	8	x \$18 (x \$9)	\$144.00
Independent Claims	1 - 3 =	0	x \$78 (x \$39)	0
Multiple Dependent Claims			\$260 (\$130)	0
Assignment Recording Fee per property			\$40	0
Surcharge Under 37 C.F.R. 1.16(e)			\$130 (\$65)	\$130.00
			TOTAL FEE:	\$1,034.00

METHOD OF PAYMENT:

A check in the amount of the above TOTAL FEE is attached. If payment by check is NOT enclosed, it is requested that the Patent and Trademark Office advise the undersigned of the period of time within which to file the TOTAL FEE. If payment enclosed, this amount is believed to be correct; however, the Commissioner is hereby authorized to charge any deficiency or credit any overpayment to Deposit Account No. 19-0741.

Respectfully submitted,

Date: November 8, 1999
Docket No.: 085874/0193


Alan I. Cantor
Registration No. 28,163

The PTO did not receive the following
listed item(s)

TITLE: LOUDSPEAKERS

This application is a continuation-in-part of application No. 08/707,012, filed September 3, 1996.

5 This application also claims the benefit of provisional application No. 60/150,817, filed August 26, 1999, and provisional application No. 60/150,824, filed August 26, 1999. The disclosures of all three of these applications are incorporated herein by reference.

10

DESCRIPTIONTECHNICAL FIELD

15 The invention relates to loudspeakers.

It is an object of the invention to provide means whereby sound from a loudspeaker can be channelled to one or more remote locations.

BACKGROUND ART

20 It is known from WO98/43464 of New Transducers Limited to provide a personal computing device of the kind having a body comprising a keyboard and a lid hinged to the body and comprising a display screen, characterised by a resonant panel loudspeaker in or attached to the lid and an acoustic
25 waveguide or horn directing acoustic output from the loudspeaker in a desired direction.

DISCLOSURE OF INVENTION

According to the invention, there is provided a loudspeaker comprising a phase uncorrelated diffuse sound source and a duct or wave guide coupled to the sound source to direct acoustic energy from the source, the duct or wave guide having a substantially parallel section extending from the vicinity of the sound source and a termination positioned remotely from the source.

The sound source may comprise a bending wave mode acoustic radiator panel. A transducer may be fixed to the panel to excite resonant bending waves therein, the resonant bending wave modes associated with each of the axes of the panel being arranged to be interleaved in frequency and the transducer location being chosen preferentially to couple to the resonant bending wave modes.

The duct may be shaped as a narrow slot in cross-section, or may be of any other desired cross-sectional shape.

The duct may be terminated by a horn section.

The panel may be located in the duct to couple acoustic radiation from both sides of the panel.

An acoustic reflector may be coupled to the duct and to the sound source to direct acoustic radiation into the duct.

The duct may have a plurality of terminations and these may be spaced along the duct.

A plurality of the panels may be coupled to the duct.

The duct may be folded.

The loudspeaker may comprise an attenuator controlling sound output from a duct termination.

Means may be provided for subdividing the duct into a plurality of wave guides extending along the duct. The duct may be subdivided in two directions, i.e. laterally and vertically.

An acoustic reflector may be disposed to direct the acoustic output from a duct termination.

10 Enclosure means may enclose one face of the panel.

The plane of the panel may be parallel to the axis of the duct.

Although the invention has been described in terms of a loudspeaker, it will be appreciated that it may find 15 other applications, e.g. as a microphone or as an acoustic absorber, whether passive or active.

BRIEF DESCRIPTION OF DRAWINGS

The invention is diagrammatically illustrated, by way of example, in the accompanying drawings in which:-

20 Figure 1 is a front partial cross-sectional view of a first embodiment of loudspeaker of the invention;

Figure 2 is a cross-sectional side view of the loudspeaker of Figure 1;

Figure 3 is a front cross-sectional view of a second 25 embodiment of loudspeaker of the invention;

Figure 4 is a cross-sectional side view of a third embodiment of loudspeaker of the invention;

Figure 5 is a cross-sectional side view of a fourth embodiment of loudspeaker of the invention;

Figure 6 is a cross-sectional side view of a fifth embodiment of loudspeaker of the invention;

5 Figure 7 is a cross-sectional side view of a sixth embodiment of loudspeaker of the invention;

Figure 8 is a cross-sectional side view of a seventh embodiment of loudspeaker of the invention;

Figure 9 is a detail of a modification;

10 Figure 10a is a schematic side view of an eighth embodiment of loudspeaker of the invention;

Figure 10b is a schematic side view of a ninth embodiment of loudspeaker of the invention;

15 Figure 11 is a schematic side view of a tenth embodiment of loudspeaker of the invention;

Figure 12a is a perspective view showing one form of attenuator for a duct termination; and

Figure 12b is a perspective view showing another form of attenuator for a duct termination.

20 BEST MODES FOR CARRYING OUT THE INVENTION

The invention relies on largely phase uncorrelated, diffuse radiation properties of a sound source or generator e.g. a flat resonant bending wave panel, for example of the kind described in parent application 08/707,012 (and in 25 counterpart publication WO97/09842) to allow coupling to an acoustic fluid, normally air, contained in a shallow volume well coupled to the source of sound energy. In contrast to the coupling aspects of correlated e.g. piston devices

which suffer problems due to path length differences, phase cancellations and subsequent power irregularities, a diffuse source allows for good integration of acoustic power over its radiating surface and that power may be conducted via fluid coupling to a remote point via a duct. Modal resonances which are normally severe in such a duct are mitigated due to the diffuse uncorrelated nature of the acoustic energy entering the duct.

The duct termination may radiate directly, which if in the form of a narrow slot or similar aperture has wide directivity and is not frequency controlling or frequency selective. If modified directive properties are required then various sizes shapes and combinations of acoustic horn known to the art may be added to the open end of the duct.

The principle of diffuse coupling may extend to simple single reflective elements acting as vestigial horns or part ducts, and the length of the duct may be varied to a point where the horn section is almost directly presented to the diffuse source.

A notable feature of the invention is that the duct can be presented in the plane of the radiator and achieve effective action. Also the sound energy on the surface of the source can be divided and directed down more than one duct or wave guide, and these may be of unequal lengths and if required the several outputs may be recombined smoothly after passage down the ducts or wave guides.

Twin ducts may be used to utilise the energy from both sides of the diffuse source. The preferred source is one

or more bending wave panels but other such sources include an array of small conventional piston speakers fed phase randomised signals or an array of digital speaker elements driven by signals suitably processed to provide a diffuse
5 acoustic function. The duct provides a beneficial integrating function which may be designed as a low pass acoustic filter to complete the desired response from an array element digital speaker.

The twin ducts may be laterally disposed to provide
10 sound at two separated locations e.g. across the passenger compartment of a vehicle benefiting from a single centrally or near centrally located sound generator.

The duct may be straight, curved or folded to allow a slim assembly to be fitted into difficult locations where
15 conventional speaker could not be placed.

Wide range sound may ducted to substantially small radiating apertures, for example the slots (normally disguised behind an acoustically transparent grille) at the sides of a television monitor. Duct performance may be
20 further enhanced by cellular subdivision to inhibit cross standing waves.

The duct and/or horn has a low frequency loading function which may be simply calculated using lumped parameters. This may beneficially load the sound source to
25 enhance the low range performance by added/matched air mass and by a baffle effect due to extended path length between the front and rear of the sound generators where relevant.

The rear of the panel or multiple panel (with same or frequency selective/differential area drive/form) or multiple cone type sound generators may have a partially or wholly enclosed rear chamber(s) for additional resonant 5 enhancement and control of the low frequency acoustic path between front and rear.

Duct height and/or cross sectional area is influential in determining the higher frequency point for smooth transmission of sound energy. Thus a rectangular duct of 10 30mm height will show some frequency dependency above 10kHz, whereas a 10mm section will perform well to beyond 25kHz.

In addition to lateral subdivisions of the duct, the sub division of the duct may be extended to the vertical 15 direction to subdivide the duct still further for maintained transmission performance at higher frequencies.

The exit area of duct driven by a diffuse source has an influence on loudness and relative to the intrinsic area of the exit a variable area mechanism such as a movable 20 blanking plate over the duct termination may provide a convenient and effective form of loudness control without a significant loss in sound quality. A horn directive element may be applied after the mechanical loudness control device. Thus a user volume control may be remote 25 from the sound generator. Alternatively a duct control device may be provided at any convenient location along the duct.

A horn termination is driven well by the duct of the invention, and the horn can provide an effective and calculable control of directivity for a diffuse source. The duct termination alone provides uniform wide angle 5 radiation, an almost perfect slot or near point source.

In respect of coincidence effects which may result in off axis lobes of power at discrete frequencies for particular designs of bending wave panel, the fluid coupling and duct integration action reconfigures the sound 10 energy such that the directive effects of coincidence are no longer a feature of the resultant acoustic output.

The duct can be any length, and terminations may be provided along the length of the duct to give a simple distributed low level sound system. Multiple resonant 15 panels could feed a duct, and a multiple panel arrangement could be made more compact by folding or bending the region in front of the panel, before the duct.

In the drawings, and referring to Figures 1 and 2 20 there is shown a loudspeaker 1 comprising a resonant bending-wave panel 2 generally of the kind described in parent application 08/707,012 (and in WO97/09842), which is driven by a vibration exciter 3 fed with an electrical audio signal from a suitable audio amplifier (not shown). 25 The panel 2 is resiliently mounted by its edges on a resilient suspension 4 in a housing 5 in the form of a parallel sided shallow slot-like duct 6 having a closed end 7 and an open end 8 which opens into a flared horn

section 9 which ends at opening or termination 10. The housing may be made from any suitable non resonant material such as those materials from which loudspeaker enclosures are normally constructed, e.g. medium density 5 fibreboard or plastics. Alternatively, at least the duct may be made of a flexible material, provided that it is suitably dense so as to be substantially non resonant in the frequency range of its intended use. Thus the duct may be in the form of a flexible pipe, e.g. of high 10 density polyethylene or the like.

The duct and horn sections are subdivided into wave guides 11 by dividers 12 extending along the duct and horn sections.

Figure 3 shows an embodiment of a loudspeaker very 15 similar to that of Figures 1 and 2. In this case, however, the inner or closed end 7 of the duct 6 is formed as a curved, e.g. parabolic, reflector to reflect acoustic radiation from the panel 2 towards the open end of the duct. Also in this embodiment, the plane of the 20 panel 2 is set at right angles to the direction of the duct whereas in Figures 1 and 2 the plane of the panel is disposed in the direction of the duct. Furthermore in this embodiment the horn section is outwardly flared or curved, whereas in the embodiment of Figures 1 and 2, the 25 horn section is conical.

Figure 4 shows a loudspeaker arrangement generally as shown in Figures 1 and 2 above and in which a housing 5 defining a parallel sided duct 6 has an open end 8

which terminates the duct, and a closed end 7. The housing supports a resonant bending-wave panel 2 on a resilient suspension 4 so that acoustic radiation from one face 17 of the panel facing into the housing 5 is directed along the duct to a remote location wherein the sound radiation is emitted from the open end of the duct.

The loudspeaker shown in Figure 5 is the same as that shown in Figure 4 except that the duct is terminated by a horn 9.

10 The loudspeaker of Figure 6 is similar to that of Figure 5, but in this case the acoustic radiation from the side 15 of the panel facing away from the duct is contained within a cavity 14 defined by an enclosure 13 fixed to or integral with the housing 5 to prevent 15 radiation from the side 15 of the panel 2 from reaching the ambient surroundings.

The loudspeaker of Figure 7 is similar to that of Figure 4 and in this case the housing 5 defines an opposed pair of parallel sided ducts 6, one being 20 associated with each face or side 15 of the panel 2, the ducts extending in opposite directions towards their open ends 8.

Figure 8 is a modification of the loudspeaker of Figure 7 and in which the two ducts 6 each associated 25 with one face of the panel 2 extend in the same direction and in spaced relation.

Figure 9 shows that the termination 8 of a duct 6 of a loudspeaker as described above may be modified by

placing an acoustic reflector 16 adjacent to the duct termination to focus and direct the sound in the direction shown by the arrows. Thus the reflector is in the form of a parabolic reflector.

5 Figures 10a and 10b show two forms of a bent or folded duct fed by multiple resonant panels.

In the embodiment of Figure 10a, duct 26 has three angularly disposed rear segments 29a, 29b, 29c. Each rear segment has a resonant panel 22a, 22b, 22c,
10 respectively. The rear of the duct is closed at 27, and the combined acoustic output of panels 22a, 22b, 22c is emitted through duct opening or termination 28.

In the embodiment of Figure 10b, duct 36 has ten angularly disposed rear segments which effectively form a
15 generally curved rear duct section. Each of the ten rear segments has a resonant panel 32a-32j. The rear of the duct is closed at 37, and the combined acoustic output of panels 32a-32j is emitted through duct opening or termination 38.

20 Figure 11 shows an embodiment having a straight duct 46 with multiple outlets or terminations for the acoustic energy emanating from resonant panel 42. Outlet 48a is located at the very end of duct 46, while a plurality of ports 48b-48e are located along duct 46 and direct sound
25 in a direction perpendicular to the output of outlet 48.

Figures 12a and 12b show two forms of loudness control devices located at the outlet or termination of the duct.

In the embodiment of Figure 12a, an attenuator panel 53 having a handle 54 is hinged to duct 56 at one edge 55 of duct termination 58 to control the acoustic energy emanating from duct termination 58.

- 5 In the embodiment of Figure 12b, an attenuator panel 63 having a handle 64 is slidably retained on duct 66 in tracks 65 at the opposite sides of duct termination 68 to control the acoustic energy emanating from duct termination 68.

10

INDUSTRIAL APPLICABILITY

The present invention thus provides a simple loudspeaker mechanism for ducting sound to remote location.

CLAIMS

1. A loudspeaker comprising a phase uncorrelated diffuse sound source and a duct or wave guide coupled to the sound source to direct acoustic energy from the source, the duct or wave guide having a substantially parallel section extending from the vicinity of the sound source and a termination positioned remotely from the sound source.
2. A loudspeaker according to claim 1, wherein the sound source comprises a bending wave mode acoustic radiator panel.
3. A loudspeaker according to claim 2, comprising a transducer fixed to the panel to excite resonant bending waves therein, the resonant bending wave modes associated with each of the axes of the panel being arranged to be interleaved in frequency and the transducer location being chosen preferentially to couple to the resonant bending wave modes.
4. A loudspeaker according to claim 3, wherein the duct is shaped as a narrow slot in cross-section.
5. A loudspeaker according to claim 4, wherein the duct is terminated by a horn section.
6. A loudspeaker according to claim 2, wherein the panel is located in the duct to couple acoustic radiation from both sides of the panel.
7. A loudspeaker according to claim 2, comprising an acoustic reflector coupled to the duct and to the sound source to direct acoustic radiation into the duct.

8. A loudspeaker according to claim 2, wherein the duct has a plurality of terminations.
9. A loudspeaker according to claim 2, comprising a plurality of the panels coupled to the duct.
- 10 10. A loudspeaker according to claim 2, wherein the duct is folded.
11. A loudspeaker according to claim 2, comprising an attenuator controlling sound output from a duct termination.
- 10 12. A loudspeaker according to claim 2, comprising means subdividing the duct into a plurality of wave guides extending along the duct.
13. A loudspeaker according to claim 12, wherein the duct is subdivided in two directions.
- 15 14. A loudspeaker according to claim 2, comprising an acoustic reflector disposed to direct the acoustic output from a duct termination.
15. A loudspeaker according to claim 2, comprising enclosure means enclosing one face of the panel.
- 20 16. A loudspeaker according to claim 2, wherein the plane of the panel is parallel to the axis of the duct.
17. A loudspeaker according to claim 1, wherein the duct is shaped as a narrow slot in cross-section.
18. A loudspeaker according to claim 17, wherein the duct
25 is terminated by a horn section.
19. A loudspeaker according to claim 1, wherein the duct is terminated by a horn section.

20. A loudspeaker according to claim 1, comprising an acoustic reflector coupled to the duct and to the sound source to direct acoustic radiation into the duct.

21. A loudspeaker according to claim 1, wherein the duct
5 has a plurality of terminations.

22. A loudspeaker according to claim 1, wherein the duct is folded.

23. A loudspeaker according to claim 1, comprising an attenuator controlling sound output from a duct
10 termination.

24. A loudspeaker according to claim 1, comprising means subdividing the duct into a plurality of wave guides extending along the duct.

25. A loudspeaker according to claim 24, wherein the duct
15 is subdivided in two directions.

26. A loudspeaker according to claim 1, comprising an acoustic reflector disposed to direct the acoustic output from a duct termination.

27. A loudspeaker according to claim 1, comprising
20 enclosure means enclosing one face of the panel.

28. A loudspeaker according to claim 1, wherein the plane of the panel is parallel to the axis of the duct.

ABSTRACTTITLE: LOUDSPEAKERS

5

A loudspeaker comprising a phase uncorrelated diffuse sound source and a duct or wave guide coupled to the sound source to direct acoustic energy from the source, the duct
 10 or wave guide having a substantially parallel section extending from the vicinity of the sound source and a termination positioned remotely from the panel.

Figure 1

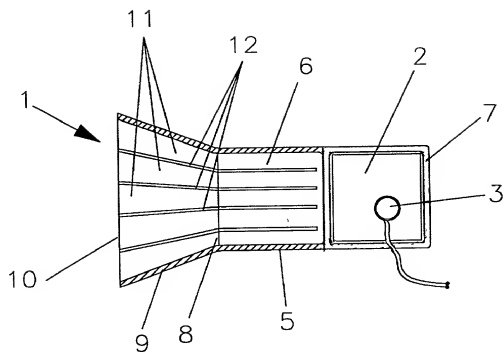


Figure 2

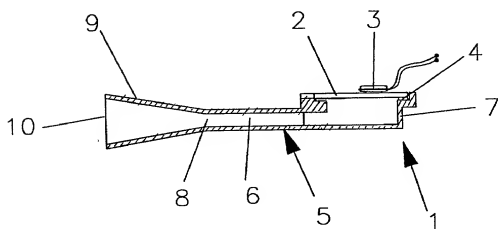


Figure 3

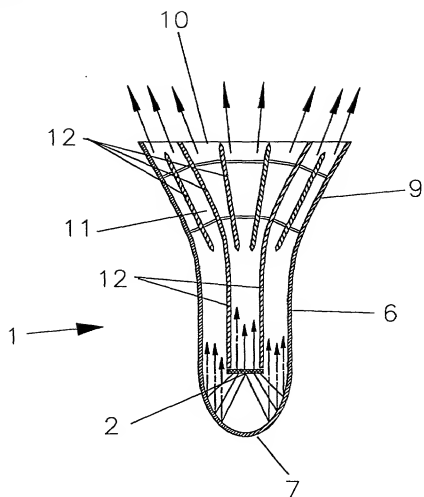


Figure 4

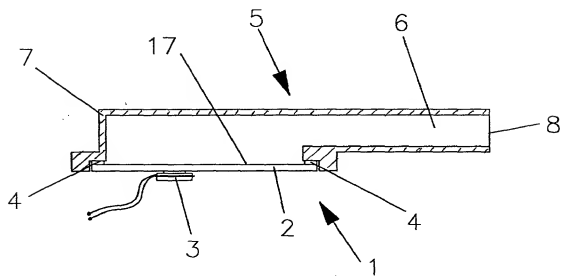


Figure 5

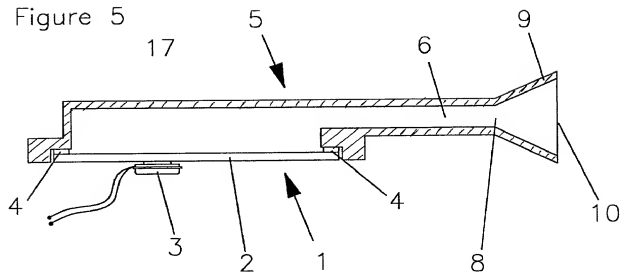


Figure 6

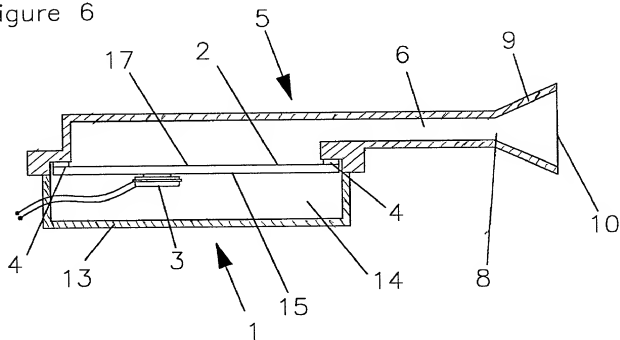


Figure 7

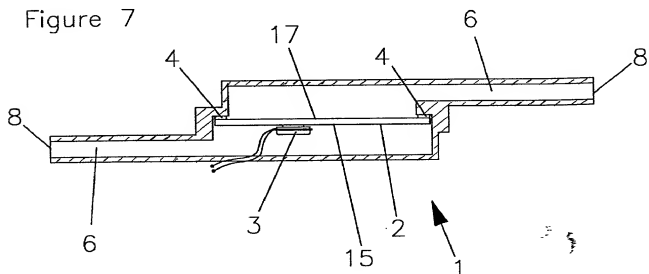


Figure 8

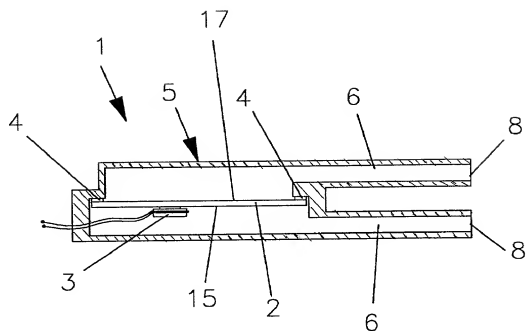


Figure 9

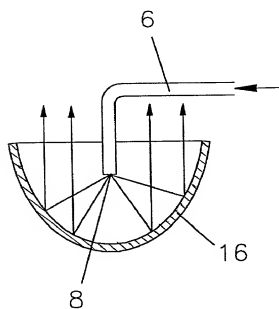


Figure 10a

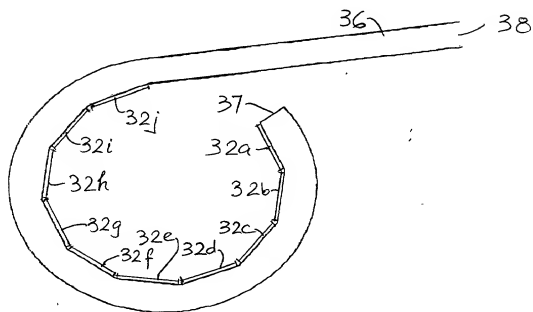
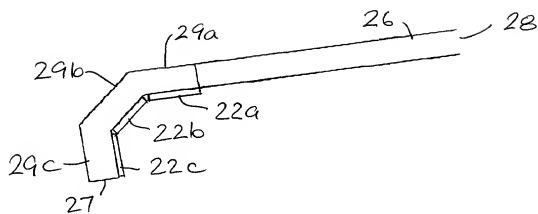


Figure 10b

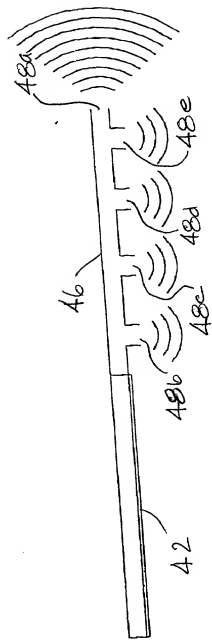


Figure 11

Figure 12a

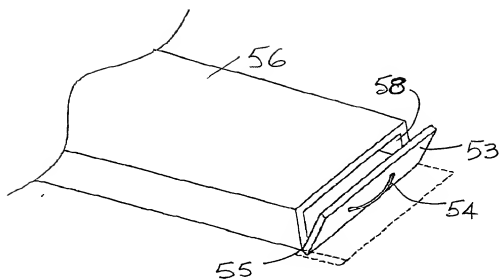
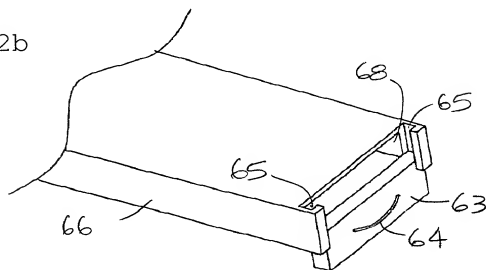


Figure 12b



DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

LOUDSPEAKERS

the specification of which is attached hereto unless the following box is checked:

☒ was filed on November 8, 1999 as United States Application Number or PCT International Application Number _____ and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is known by me to be material to patentability as defined in Title 37, Code of Federal Regulations § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

NUMBER	COUNTRY	DAY/MONTH/YEAR FILED	PRIORITY CLAIMED
9824255.5	United Kingdom	6 November 1998	Yes
9914410.7	United Kingdom	22 June 1999	Yes

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below.

APPLICATION NO.	FILING DATE
60/150,817	August 26, 1999
60/150,824	August 26, 1999

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is known by me to be material to patentability as defined in Title 37, Code of Federal Regulations § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

APPLICATION SERIAL NO.	FILING DATE	STATUS: PATENTED, PENDING, ABANDONED
08/707,012	September 3, 1996	Pending

I hereby appoint as my attorneys, with full powers of substitution and revocation, to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: Stephen A. Benit, Reg. No. 29,768; David A. Blumenthal, Reg. No. 26,257; William T. Ellis, Reg. No. 26,874; John J. Feldhaus, Reg. No. 28,822; Patricia D. Granados, Reg. No. 33,683; John P. Isaacson, Reg. No. 33,715; Donald D. Jeffery, Reg. No. 19,980; Eugene M. Lee, Reg. No. 32,039; Peter G. Mack, Reg. No. 26,001; Brian J. McNamara, Reg. No. 32,789; Sybil Meloy, Reg. No. 22,749; George E. Quillin, Reg. No. 32,792; Colin G. Sandercock, Reg. No. 31,298; Bernhard D. Saxe, Reg. No. 28,665; Charles F. Schill, Reg. No. 27,590; Richard L. Schwaab, Reg. No. 25,479; Arthur Schwartz, Reg. No. 22,115; Harold C. Wegner, Reg. No. 25,258; Alan I. Cantor, Reg. No. 28,163.

Address all correspondence to FOLEY & LARDNER, Washington Harbour, 3000 K Street, N.W., Suite 500, P.O. Box 25696, Washington, D.C. 20007-8696. Address telephone communications to Alan I. Cantor at (202) 672-5300.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of First or Sole Inventor <i>Neil HARRIS</i>	Signature of First or Sole Inventor	Date
Residence Address <i>Cambridge, United Kingdom</i>	Country of Citizenship <i>United Kingdom</i>	
Post Office Address <i>9 Davey Crescent, Great Shelford, Cambridge CB2 5JF, United Kingdom</i>		

Full Name of Second Inventor <i>Graham BANK</i>	Signature of Second Inventor	Date
Residence Address <i>Cambridgeshire, United Kingdom</i>	Country of Citizenship <i>United Kingdom</i>	
Post Office Address <i>1 Boartree Way, Huntingdon, Cambridgeshire PE18 6GL, United Kingdom</i>		

Full Name of Third Inventor	Signature of Third Inventor	Date
Residence Address	Country of Citizenship	
Post Office Address		

Full Name of Fourth Inventor	Signature of Fourth Inventor	Date
Residence Address	Country of Citizenship	
Post Office Address		

Full Name of Fifth Inventor	Signature of Fifth Inventor	Date
Residence Address	Country of Citizenship	
Post Office Address		